is followed more closely than in previous editions, and the inorganic portion of the volume rather than the organic has been developed in accordance with the increased attention which, the editors say, has been directed to inorganic chemistry of late years. Precise details from original memoirs, outside the scope of the ordinary text-book, have been included and will increase the value of the work for more advanced students.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Distance of the Visible Horizon.

THE subject of terrestrial refraction and its effect on the distance of the visible horizon, about which Mr. Backhouse inquires in NATURE of September 25, is very fully discussed in the second volume of Jordan's "Handbuch der Vermessungskunde." The formula there proved is

$$a = \sqrt{\frac{2r}{1-k}h}$$

where a = distance of visible horizon.
r = earth's radius.
k = coefficient of refraction (mean value 0·13).
h = height of observer.

This formula reduces to

Distance in statute miles $= 1{\cdot}312\sqrt{\text{height in feet}}$.

The subject is also discussed in Gillespie's "Higher Surveying," where, using a slightly different coefficient of refraction, the formula arrived at is very nearly the same, viz. :—

Distance in statute miles $= 1{\cdot}317\sqrt{\text{height in feet}}$.

It is easy to construct a table from either of these formulæ which will give the distance of the visible horizon at any height under average atmospheric conditions.

The method of reducing trigonometric heights described by Capt. Tizard, where the refraction-angle is taken at 5″ for each nautical mile of distance, is equivalent to using a refraction-coefficient of 0·18 in place of Jordan's 0·13. My own experience in the Red Sea and Gulf of Suez is that Jordan's value is tolerably correct near midday in winter and spring; this would imply that 4″ per nautical mile of distance is a nearer value than Capt. Tizard's 5″ under those conditions, and as a matter of fact the substitution of the lesser value leads to a rather better agreement for the height of Jebel Hooswah than that shown in Capt. Tizard's table.

Abnormalities of refraction, such as Capt. Tizard notes, are tolerably frequent over tropical seas, and one naturally avoids making measurements of altitude when the conditions are palpably abnormal. The variation of 18° in the altitude of the horizon in the Arctic regions, quoted by Capt. Tizard, is doubtless a misprint for 18′ or 18″; but in any case such a figure is meaningless unless the height of the observation-point is given.

It is not temperature *per se* which affects refraction, so much as the vertical temperature-gradient in the air; this varies very rapidly in the early morning hours, but becomes more steady about noon. I have found that at fair altitudes the refraction is in general wonderfully constant in the middle of the day, say between 11.30 a.m. and 3 p.m.; and by restricting observations for level to this time of the day I have obtained very much more concordant results than those quoted by Capt. Tizard. If the object is only visible in the early morning or late evening, an evening observation is much to be preferred to a morning one

The table given by Capt. Tizard is liable to give an exaggerated impression of the range of refraction. The differences of height found for the same point by his various observations probably depend not so much on variations in refraction, as on the roughness of the angular observations; in all cases except two, his depression-angles are only given to minutes, and a minute of arc at a distance of fifty-eight nautical miles subtends more than 100 ft. It is easy nowadays to measure the vertical angles well within 5″ of the truth, using only a 6-in. micrometer-theodolite; but perhaps in 1871 the instruments available were of a less accurate nature, and one must not be too critical of the results obtained. I would, however, venture to point out that it is incorrect to take the arithmetic mean of the heights from a number of observations at different distances when the least certain factor in the height (the correction to the height due to refraction) varies as the square of the distance; and it is scarcely scientific to correct for refraction to single seconds when the observations themselves are only taken to the nearest minute, or to calculate heights to four significant figures from distances given only to three.

JOHN BALL.

Survey Department, Cairo, October 2.

WITH reference to the remarks of Dr. John Ball, I am much obliged to him for directing my attention to Jordan's "Handbuch der Vermessungskunde" and Gillespie's "Higher Surveying," two works with which I was previously unacquainted.

The coefficient for refraction given by Jordan is the mean of a number of results by different observers in different countries, the originals varying from 0·105 to 0·167.

These results show that the refraction is a very variable quantity, and that the results inland are different from those near the sea. In Gillespie's work he shows how the refraction varies at different hours in the day on the coast of California (*a*) from a height of 57 metres, and (*b*) from a height of 1173 metres, being least near noon, and greatest in the morning and evening. From the height of 57 metres the coefficient varied from 0·14 to 0·10, whilst from the height of 1173 metres it varied from 0·09 to 0·06.

Gillespie publishes curves showing the results obtained. But he points out that the refraction is a very variable quantity, and it is doubtful whether the same curves would be obtained at all seasons at the same place. These are the very observations that are required.

It is quite true, as Dr. Ball points out, that if at Jebel Hooswah a refraction of 4 seconds instead of 5 per mile was used the results would be in closer accordance, but he does not appear to have seen that if a refraction of 6 seconds instead of 5 per mile was used for the Jebel Serbal observations they would be still more in accordance with each other. Therefore on different days and from different heights the results in the one case would be closer if the coefficient for refraction was decreased, and in the other if it was increased. Abnormal refractions are more common in high than in low latitudes; the greatest I have seen personally was in the Baltic Sea.

With reference to Dr. Ball's observations on the table given by me I reply as follows :—

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(1) The observations were obtained by a 5-in. theodolite reading to 30″ of arc.

(2) That the results given from angles of depression from Jebel Serbal to points nearly 180° apart show (*a*) that the theodolite was in perfect adjustment, and that the height obtained from a distance of fifty-eight miles on the north side differed only 116 ft. from the height obtained at a distance of 24·9 miles on the south side.

(3) Although observations obtained with imperfect instruments—and what instrument is perfect?—may give results not perfectly accurate, I cannot admit that the corrections applied should not be as accurate as they can be.

(4) Dr. Ball is correct in stating that a distance of fifty-eight miles an error of one minute in the angle of depression means a difference of about 100 ft. in the result.

(5) He is also correct in his surmise that the variation in altitude of the horizon in the Arctic should be 18 minutes and not 18 degrees. This is a printer's error.

T. H. TIZARD.

The Piltdown Skull and Brain Cast.

THE excellent figure of the Piltdown brain cast which accompanied Prof. Elliot Smith's last letter (NATURE, November 13, p. 318) brings out clearly the differences which separate him and me. His figure represents a brain with approximately symmetrical right and left hemispheres, so far as these are viewed from the hinder or occipital aspect. If, then, the anatomical parts occupy corresponding positions on the two sides, he has solved the problem of how to reconstruct the Piltdown skull so as to obtain a considerably smaller brain than I had postulated. I have made a tracing of his reconstruction in order to fill in with some details the exact relationship of parts represented by his drawing. It will be seen he has obtained symmetry by the most simple means. In the original brain cast the right hemisphere of the brain measured only 555 cubic centimetres, the left half 645 c.c.; this difference of 90 c.c. referred only to the hinder part of each hemisphere. In Prof. Elliot Smith's reconstruction the hemispheres have been balanced by moving the left hemisphere towards or beyond the middle line and enlarging the left hemisphere. The middle line which Prof. Elliot Smith has selected is exactly that used by Dr. Smith Woodward in the reconstruction of the skull, not that which he employed when building up the brain cast; in building up the brain he employed another middle-line altogether.

In the accompanying tracing of Prof. Elliot Smith's reconstruction I have indicated the longitudinal blood sinus which sweeps widely (10 mm.) to the right as it passes between the occipital poles of the brain. The left pole exceeds the right to a degree which is seldom seen in even the highest forms of modern human brains. Seven years ago Prof. Elliot Smith published a short paper (*Anat. Anz.*, 1907, vol. xxx., p. 574), which is justly regarded as authoritative. He directed attention to the preponderance of the left occipital pole of the brain, and attributed that preponderance to the specialisation of the right hand; only the slightest degree of asymmetry is observable in anthropoid apes. Indeed, at that time Prof. Elliot Smith definitely stated that he regarded symmetry of the occipital poles—in my opinion an absolutely just deduction—as a simian character. He will, therefore, if he retains the present reconstruction, have to modify to some extent the opinion he has expressed of the brain of Piltdown man—that it is "the most primitive and simian brain yet recorded." As regards the asymmetry of the occipital poles, it is, in my opinion, ultra-modern.

Prof. Elliot Smith has frankly stated that his reconstruction is not, in the strict sense of the word, a cranial cast—a cast taken from the interior of a reconstructed skull; it is a reconstruction built up—as the original brain cast must have been—from impressions taken from the inner or cerebral aspect of the cranial bones. To test such a brain reconstruction the actual fragments of the skull must be placed over the corresponding parts of the brain cast. When that is done it is at once seen that in securing a symmetry of the brain hemispheres the corresponding parts of the skull are thrown somewhat out of position. On the tracing of the reconstruction (Fig. 1) I have drawn a line, *x*—*y*, across corresponding angles of the parietal bones. That of the right side is a centimetre higher than on the left; on the right side the lambdoid suture passes outside the 50 mm. vertical line; on the left it stops short of that line.

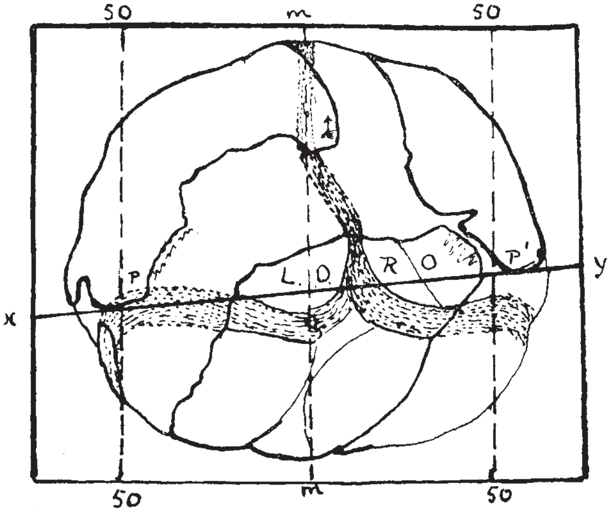

FIG. 1.—Tracing of Prof. Elliot Smith's reconstruction of the brain-cast with certain additions. (Half nat. size.)

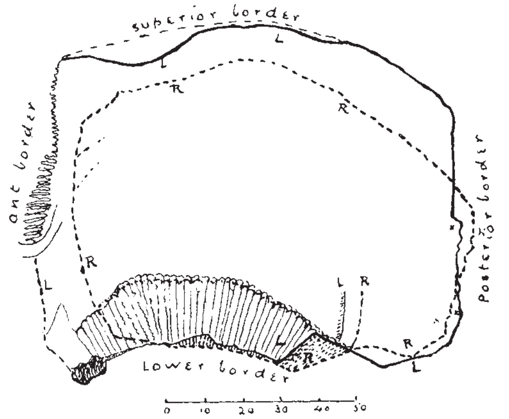

FIG. 2.—Tracing of the right fragment of the parietal (Piltdown) fragment (broken line) superimposed on the right bone (continuous line). (Half nat. size.)

It may be questioned if the hinder, lower angle of the parietal bones do correspond. That was the very first point I set out to determine when I found there was such a discrepancy between the size of the Piltdown cranial fragments and the brain capacity which Dr. Smith Woodward had ascribed to this earliest known form of man. That is the first step which has to be taken. In Fig. 2

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